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FULL LENGTH ARTICLE

Effect of broiler breeder strain and hatching eggs pre-incubation storage length on Broilers' Carcass Traits

A.A. Alsobayel *, **M.S. Rabea, M.A. Alodan**

Department of Animal Production, College of Food and Agriculture Sciences, King Saud University, Riyadh, Saudi Arabia

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KEYWORDS

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Abstract A total of 720 one day old chicks of three different commercial broiler strains (Isa, Ross and Arbor Acres), were obtained from hatching eggs stored for 0, 7 and 14 days under 70–80% relative humidity and 16–18 °C. Eighty chicks of each strain and storage period were used in the study. Chicks of each storage period were randomly divided into 4 replicates of 20 chicks in each of equal group weight and randomly allotted to 1 m × 1.5 m pens located in an environmentally controlled house. Birds were fed a starter diet to 3 weeks, followed by finisher diet to 5 weeks of age, which contain 21.5% and 18.5% crude protein and 2950 and 3100 kcal/kg metabolizable energy, respectively. At 5 weeks of age, 3 males and 3 females were randomly selected from each replicate, individually weighed and were slaughtered after they have been fasted for 12 h. Measurements were made of bird plant weight, carcass weight and its percentage of plant weight, abdominal fat weight, heart, liver and gizzard weights and their percentages of plant and carcass weight. The results of study reported herein revealed that strain and storage period of hatching eggs had a pronounced effect upon most studied traits. The results also showed that broilers of Arbor Acres and those of hatching eggs stored for seven days or less had in general the best carcass traits.

1. Introduction

Several investigators reported significant strain differences with respect to carcass characteristics of broilers (Merkley et al., 1980; Farran et al., 2000; Hulet and Lorenz, 2001; Ojedapo et al., 2008; Kosarachukwu et al., 2010; Olawumi and Fagbuaro, 2011; Shim et al., 2012; Fernandes et al., 2013; Kokoszynski et al., 2013; Malik et al., 2013). However very sparse information is available regarding the effect of preincubation storage length of hatching eggs upon carcass characteristics of broilers (Alsobayel and Al-Miman, 2010). Therefore, this study was conducted to assess the effect of strain and length of storage period of hatching eggs on broiler carcass characteristics.

* Corresponding author.
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Table 1 Composition and calculated analysis of diets used in the experiment.

Ingredients	Starter	Finisher	Unit
Metabolizable energy	2950	3100	kcal/kg
Crude protein	21.5	18.5	%Min.
Crude fat	2.5	3.0	–
Fiber	3.0	3.5	%Max.
Calcium	1.0	0.9	%Max.
Available phosphorus	0.42	0.4	%Max.
Sodium	0.15	0.15	%Max.
Lysine	1.20	1.00	%Max.
Methionine	0.50	0.45	%Max.
Meth + Cysteine	0.85	0.85	%Max.
Vit A	12,000	12,000	IU/kg
Vit D	5000	5000	IU/kg
Vit E	60	60	mg/kg
Vit C	100	100	mg/kg
Vit K	4	4	mg/kg
Vit B1	3	3	mg/kg
Vit B2	8	8	mg/kg
Vit B6	5	5	mg/kg
Vit B12	0.03	0.03	mg/kg
Niacin	40	40	mg/kg
Pantothenic acid	15	15	mg/kg
Folic acid	2	2	mg/kg
Biotin (vit H)	0.2	0.2	mg/kg
Choline (added)	900	900	mg/kg
Cobalt	0.5	0.5	mg/kg
Cooper	8	8	mg/kg
Iodine	2	2	mg/kg
Iron	35	35	mg/kg
Manganese	90	90	mg/kg
Selenium	0.2	0.2	mg/kg
Zinc	70	70	mg/kg
Antioxidant[a]	125	125	mg/kg

Ingredient: Cereals, Soya bean meal, Vegetable oil, Amino Acids, Vitamins and Minerals.

[a] 30% of Copper, manganese, zinc and selenium as Bioplex minerals coccidiostat (Avatec/Cygro).

2. Materials and method

A total of 720 one day-old chicks were obtained from hatching eggs stored for 0, 7 and 14 days of three different commercial broiler breeders at 40–44 weeks of age (Isa, Ross and Arbor Acres), 240 of each strain and 80 chicks of each storage period under 70–80% relative humidity and 16–18 °C. Following usual hatchery practices, eggs were incubated in moving air incubators under 37.5 °C and 65% relative humidity and were turned automatically 6 times a day, once every 4 h from the first day up to the 18th day of the incubation period. On the 18th day of incubation, the eggs were transformed to the hatcher where the temperature was 37 °C and relative humidity was 80%. The trays were designed to separate hatching chicks and do not allow them to move from their places and mix. The chicks for each storage period and strain were randomly divided into 4 replicates of 20 chicks in each of equal group weight. The replicates were randomly allotted to 1 m × 1.5 m pens located in an environmentally controlled house. Red sand was used as bedding materials, which have been used without negative effect on broiler performance (Alsobayel et al., 2005). Birds were fed a starter diet to 3 weeks, followed by finisher diet to 5 weeks of age, which were purchased from Arabian Agricultural Services Company (ARASCO) and contain 21.5% and 18.5% crude protein and 2950 and 3100 kcal/kg metabolizable energy (Table 1), respectively. The chicks were vaccinated in the first day against Newcastle disease by adding in drinking water. Maximum and minimum house temperature (Fig. 1) and relative humidity (Fig. 2) were daily recorded in different location during the whole experimental periods. Birds were exposed to light 24 h a day with a light intensity of 2.1, 0.71 and 0.39-foot candle for the first week, second week and the last three weeks, respectively. At 5 weeks of age, 3 males and 3 females were randomly selected from each replicate, individually weighed and were slaughtered after they have been fasted for 12 h and inspected for breast blisters and foot pad lesions. Measurements were made of bird live weight, carcass weight and its percentage of live weight, abdominal fat weight,

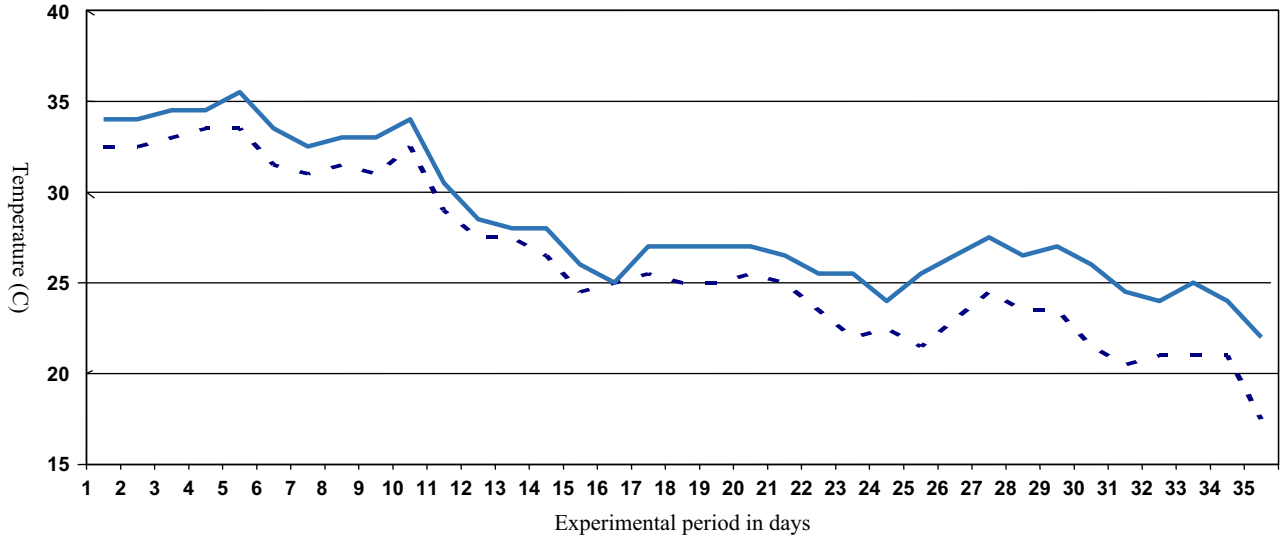

Figure 1 Average daily maximum and minimum house temperature (°C) during the whole experimental period.

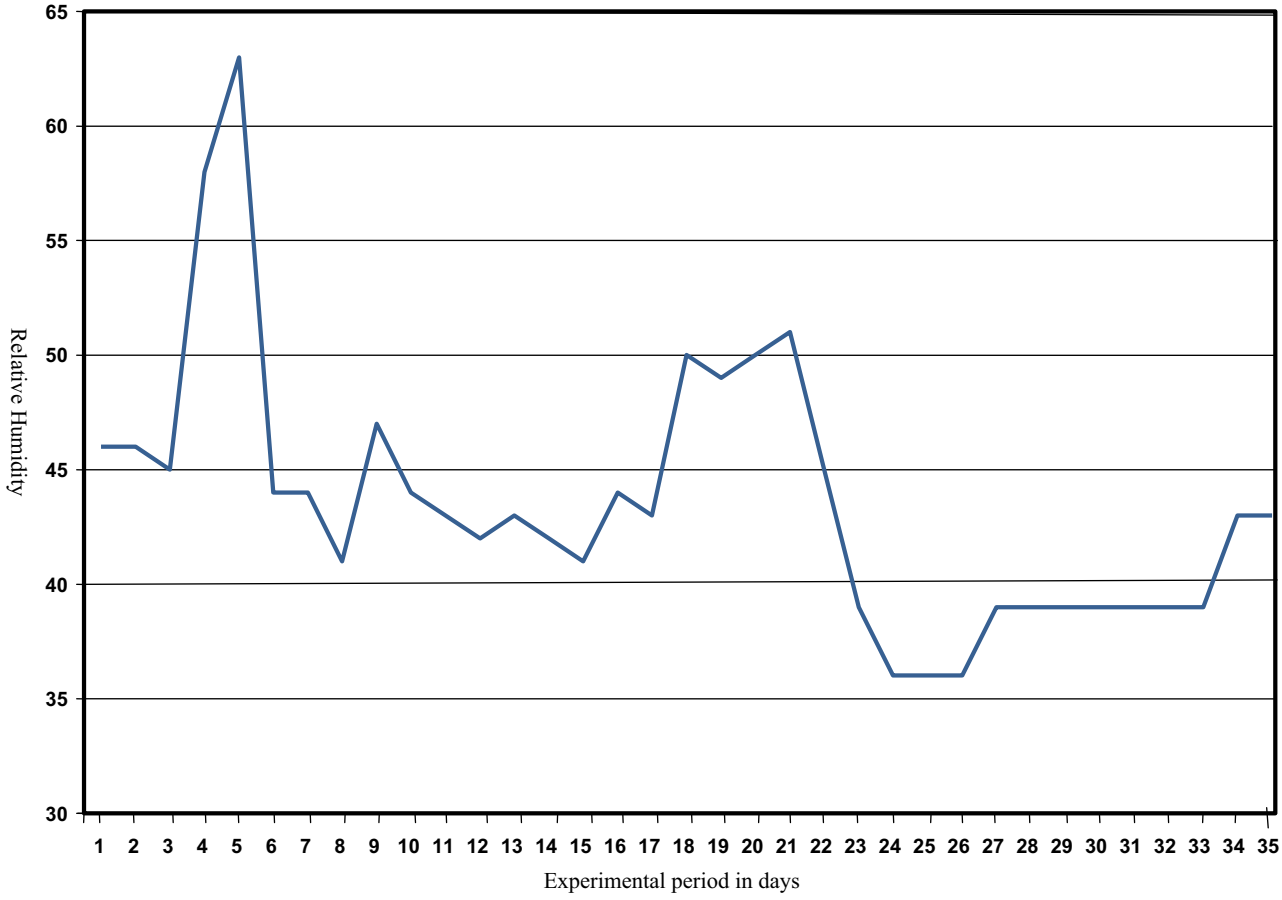

Figure 2 Average of daily relative humidity during breeding period.

Table 2 Effect of Strain (ST), Storage Period (SP) and Sex (S) on Plant Body Weight (PBW), Carcass (CW), Liver (LW), Heart (HW), Gizzard (GW) and Abdominal Fat (AFW) weights.

Parameters	PBW (gm)	CW (gm)	LW (gm)	HW (gm)	GW (gm)	AFW (gm)
ST	**	**	**	**	**	**
Isa	1310.68^{c}	946.11^{c}	26.33^{c}	8.51^{b}	31.01^{b}	19.88^{b}
Arbor	1834.90^{a}	1342.22^{a}	39.24^{a}	10.96^{b}	35.59^{a}	28.79^{a}
Ross	1709.30^{b}	1191.73^{b}	32.93^{b}	11.37^{a}	30.45^{b}	19.18^{b}
SP (days)	**	**	NS	NS	**	**
0	1710.52^{a}	1220.65^{a}	33.06	10.53	33.32^{a}	25.39^{a}
7	1596.57^{b}	1151.85^{b}	32.71	10.17	32.35^{ab}	21.67^{b}
14	1547.78^{b}	1107.56^{b}	32.74	10.15	31.38^{b}	20.79^{b}
S	**	**	**	**	**	NS
F	1505.78^{b}	1087.20^{b}	31.24^{b}	9.58^{b}	30.40^{b}	23.41
M	1730.80^{a}	1232.83^{a}	34.42^{a}	10.99^{a}	34.30^{a}	21.82
Interactions						
ST * SP	*	NS	*	NS	NS	NS
ST * S	**	*	NS	*	**	NS
SP * S	NS	NS	NS	NS	NS	NS
ST * SP * S	NS	NS	NS	NS	NS	NS
MSE	±9.022	±6.955	±0.334	±0.143	±0.303	±0.432

NS – Non-significant.
Means in the same column with different superscripts differ significantly ($p \leqslant .05$).
* Significant ($p \leqslant .05$).
** Highly significant ($p \leqslant .01$).

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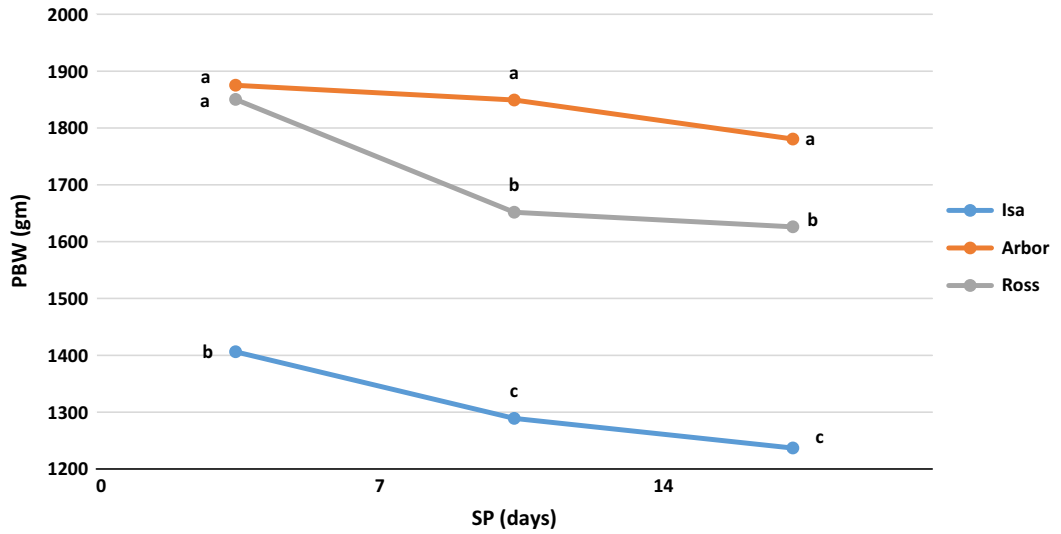

Figure 3 Effect of interaction between strain and eggs storage period (ST * SP) on Plant Body Weight (PBW).

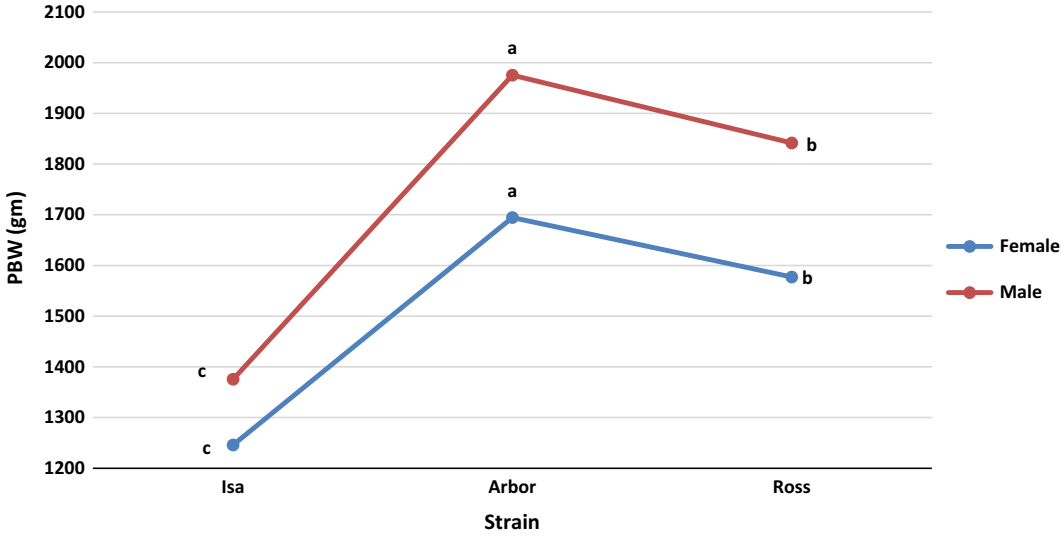

Figure 4 Effect of interaction between strain and sex (ST * S) on Plant Body Weight (PBW).

heart, liver and gizzard weights and their percentages of carcass weight.

3. Statistical analysis

Data obtained were subjected to statistical analysis using the General Linear Models (GLM) procedures of SAS Institute (2000) using the following statistical model:

$$Y_{ijkl} = \mu + ST_i + SP_j + S_k + STSP_{ij} + STS_{jk} + SPS_{ik} + STSPS_{ijk} + e_{ijkl}$$

where:

Y_{ijkl} is the lth observation of the ith strain (ST), storage period jth (SP) and kth sex (S).
$STSP_{ij}$ is the interaction between strain and storage period.
STS_{ik} is the interaction between strain and sex.
SPS_{ik} is the interaction between storage period and sex.
$STSPS_{ijk}$ is the interaction between strain, storage period and sex.
μ is the general mean.
e_{ijkl} is the random error associated with Y_{ijkl} observation.

Percentages of carcass, abdominal, liver, heart and gizzard weights were transformed to arc sin $\sqrt{}$ proportion prior to statistical analysis. In case of significant differences, LSD test was used to separate the means.

4. Results

Plant Weight (PW): Table 2 indicates that there was a significant ($p \leqslant 0.05$) strain, storage period, sex, ST * SP and ST * S effect on plant weight. Arbor Acres broilers had significantly ($p \leqslant 0.05$) the highest and Isa the lowest plant body weight whereas broilers of not stored hatching eggs and males had

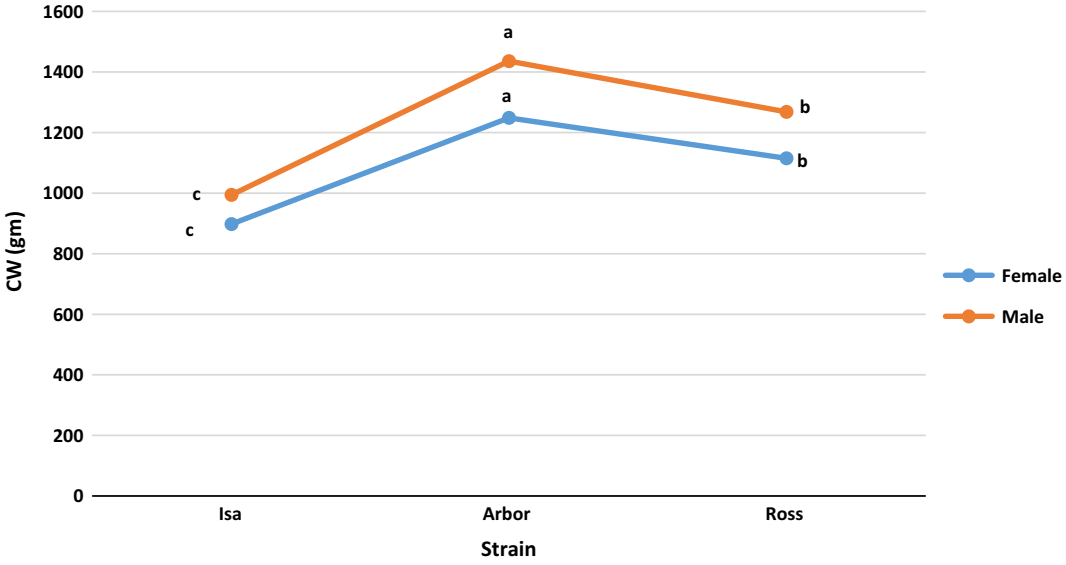

Figure 5 Effect of interaction between stain and sex (ST * S) on Carcass Weight (CW).

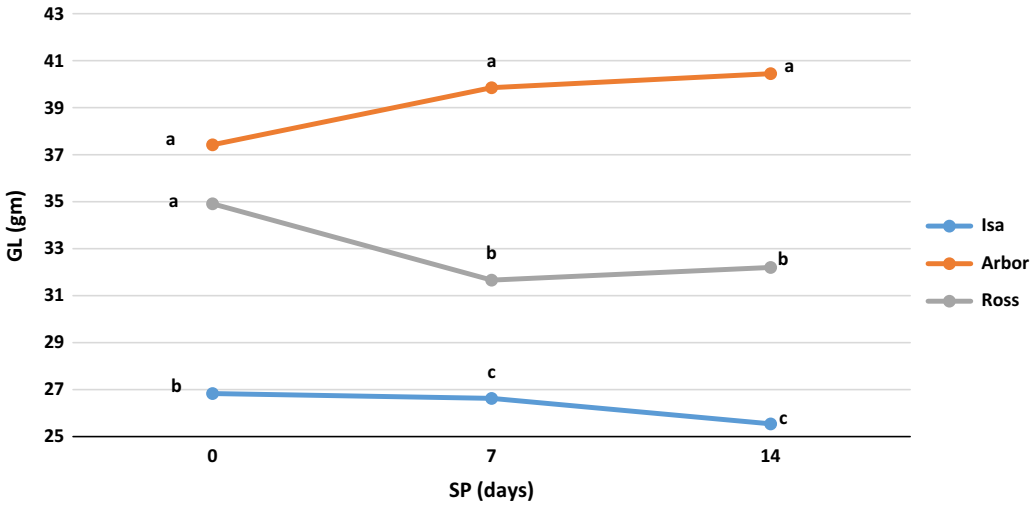

Figure 6 Effect of interaction between strain and eggs storage period (ST * SP) on Liver Weight (LW).

significantly ($p \leqslant 0.05$) higher plant weight compared to those of stored hatching eggs and females, respectively (Table 2). Fig. 3 shows that Isa broilers of stored and not stored hatching eggs had significantly ($p \leqslant 0.05$) lower plant weight than those of other strains, whereas Arbor Acres broilers of stored hatching eggs had significantly ($p \leqslant 0.05$) higher plant weight than those of Ross. As it is shown in Fig. 4 male and female broilers of Isa had significantly the lowest and those of Arbor Acres the highest plant weight.

Carcass Weight (*CW*): Table 2 shows that there was a significant ($p \leqslant 0.05$) strain, storage period, sex and SP * S effect on carcass weight. Arbor Acres broilers had significantly ($p \leqslant 0.05$) the highest and Isa the lowest carcass weight whereas broilers of not stored hatching eggs and males had significantly ($p \leqslant 0.05$) higher carcass weight compared to those of stored hatching eggs and females, respectively (Table 2). Fig. 5 shows that male and female broilers of Arbor Acres had significantly ($p \leqslant 0.05$) the highest and those of Isa the lowest carcass weight.

Liver Weight (*LW*): Table 2 shows that there was a significant ($p \leqslant 0.05$) strain, sex and ST * SP effect on liver weight. Arbor Acres broilers had significantly ($p \leqslant 0.05$) the highest and Isa the lowest liver weight whereas broilers of males had significantly ($p \leqslant 0.05$) higher liver weight compared to those of females (Table 2). Fig. 6 shows that Isa broilers of stored and not stored hatching eggs had significantly ($p \leqslant 0.05$) lower liver weight than those of other strains, whereas Arbor Acres broilers of stored hatching eggs had significantly ($p \leqslant 0.05$) higher liver weight than those of Ross.

Heart Weight (*HW*): Table 2 indicates that there was a significant ($p \leqslant 0.05$) strain, sex and ST * S effect on heart weight. Ross broilers had significantly ($p \leqslant 0.05$) the highest and Isa the lowest heart weight whereas broilers of males had significantly ($p \leqslant 0.05$) higher heart weight compared to those of

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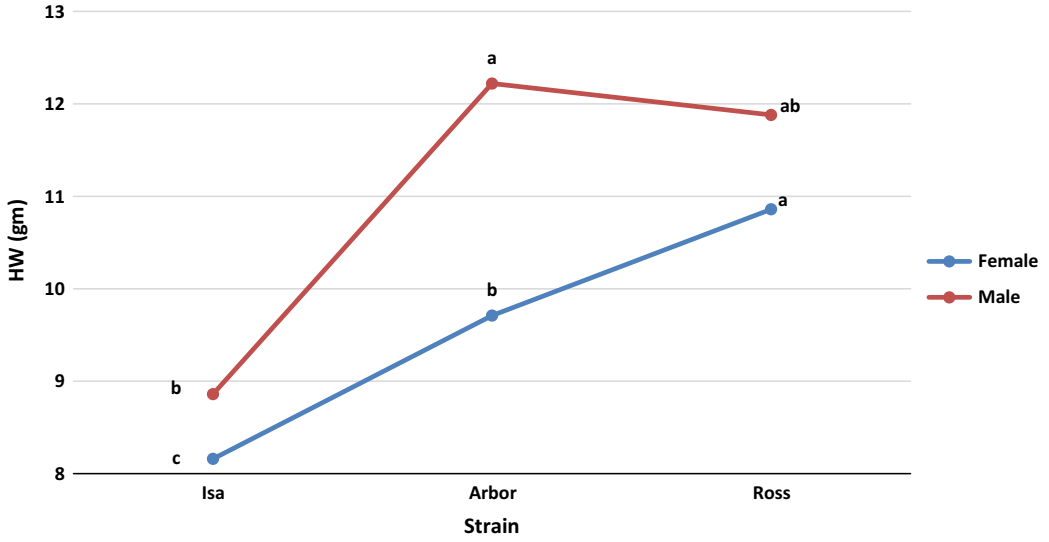

Figure 7 Effect of interaction between strain and sex (ST * S) on Heart Weight (HW).

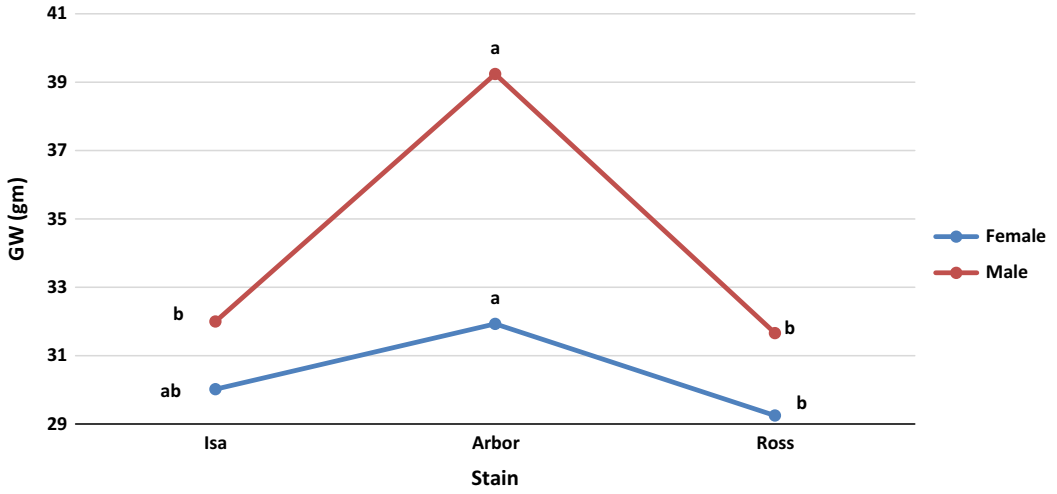

Figure 8 Effect of interaction between strain and sex (ST * S) on Gizzard Weight (GW).

females (Table 2). Fig. 7 shows that male and female broilers of Isa had significantly ($p \leqslant 0.05$) the lowest and that female broilers of Ross the highest heart weight whereas males of Ross and Arbor Acres had statically similar values.

Gizzard Weight (*GW*): Table 2 indicates that there was a significant ($p \leqslant 0.05$) strain, storage period, sex and ST * S effect on gizzard weight. Arbor Acres broilers had significantly ($p \leqslant 0.05$) the highest and Isa the lowest gizzard weight whereas broilers of not stored hatching eggs and males had significantly ($p \leqslant 0.05$) higher gizzard weight compared to those of stored hatching eggs for 14 days and females, respectively (Table 2). Fig. 8 shows that female broiler of Arbor Acres had significantly higher gizzard weight than those of Ross whereas their male broilers had higher than those of other strains.

Abdominal Fat Weight (*AFW*): Table 2 shows that there was a significant ($p \leqslant 0.05$) strain and storage period effect on abdominal fat weight. Arbor Acres broilers had significantly ($p \leqslant 0.05$) the highest and Isa the lowest abdominal fat weight whereas broilers of not stored hatching eggs had significantly ($p \leqslant 0.05$) higher abdominal fat weight compared to those of stored hatching eggs (Table 2).

Carcass percentage of plant body weight (C*P*): Table 3 indicates that there was a significant ($p \leqslant 0.05$) strain, sex and ST * SP effect on CP. Arbor Acres and Isa broilers had significantly ($p \leqslant 0.05$) the highest and Ross the lowest values whereas female broilers had significantly ($p \leqslant 0.05$) higher CP compared to those of males (Table 3). Fig. 9 shows that Ross broilers of stored for 14 days and not stored hatching eggs had significantly ($p \leqslant 0.05$) lower CP than those of other strains, whereas only Arbor Acres broilers of stored hatching eggs for 7 days had significantly ($p \leqslant 0.05$) higher CP than those of Ross.

Liver Percentage of Plant Body Weight (*LP*): Table 3 shows that there was a significant ($p \leqslant 0.05$) strain, sex and storage period effect on LP. Arbor Acres and Isa broilers had significantly

Table 3 Effect of Stain (ST), Storage Period (SP) and Sex (S) on Carcass Weight (CP), Liver (LP), Heart (HP), Gizzard (GP) and Abdominal Fat (AFP) Weights as a Percentage of Plant Body Weight (PBW).

Parameters	CP (%)	LP (%)	HP (%)	GP (%)	AFP (%)
ST	**	**	**	**	**
Isa	72.14[a]	2.01[a]	0.65[a]	2.37[a]	1.52[a]
Arbor	73.14[a]	2.14[a]	0.59[b]	1.94[b]	1.59[a]
Ross	69.92[b]	1.93[b]	0.66[a]	1.79[c]	1.12[b]
SP (days)	NS	**	NS	NS	NS
0	71.53	1.93[b]	0.62	1.98	1.50
7	72.06	2.04[a]	0.64	2.07	1.36
14	71.60	2.11[a]	0.66	2.06	1.38
S	*	*	NS	NS	**
F	72.14[a]	2.07[a]	0.64	2.05	1.55[a]
M	71.33[b]	1.98[b]	0.63	2.02	1.26[b]
Interactions					
ST * SP	**	NS	NS	NS	NS
ST * S	NS	NS	NS	*	NS
SP * S	NS	NS	NS	NS	NS
ST * SP * S	NS	NS	NS	NS	NS
MSE	±0.155	±0.018	±0.116	±0.268	±0.397

NS – Non-significant.
Means in the same column with different superscripts differ significantly ($p \leqslant .05$).
* Significant ($p \leqslant .05$).
** Highly significant ($p \leqslant .01$).

($p \leqslant 0.05$) the highest and Ross the lowest values whereas broilers of stored hatching eggs and females had significantly ($p \leqslant 0.05$) higher LP compared to those of not stored and males, respectively (Table 3). Heart Percentage of Plant Body Weight (*HP*): Table 3 indicates that there was a significant ($p \leqslant 0.05$) strain effect on HP. Arbor Acres and Ross broilers had significantly ($p \leqslant 0.05$) the highest and Isa the lowest values (Table 3).

Gizzard Percentage of Plant Body Weight (*GP*): As it is shown in Table 3 there was a significant ($p \leqslant 0.05$) strain and ST * S effect on GP. Arbor Acres and Ross broilers had significantly ($p \leqslant 0.05$) the highest and Isa the lowest values (Table 3). Fig. 10 shows that male and female broilers of Isa had significantly ($p \leqslant 0.05$) the highest and that female and male broilers of Ross the lowest GP whereas broilers of Ross and Arbor Acres had statically similar values.

Abdominal Fat Percentage of Plant Body Weight (*AFP*): Table 3 indicates that only strain and sex had a significant ($p \leqslant 0.05$) effect on AFP. Ross broilers had significantly ($p \leqslant 0.05$) the lowest value compared with those of other strains whereas female broilers had significantly ($p \leqslant 0.05$) higher AFP than their male counterparts (Table 3).

Liver Percentage of Carcass Weight (*LPC*): Table 4 indicates that only storage period had a significant ($p \leqslant 0.05$) effect on LPC. Broilers of stored hatching eggs for 14 days had significantly ($p \leqslant 0.05$) higher LPC than those of not stored whereas broilers of stored hatching eggs for 7 days had statically similar values as those of other treatments (Table 4).

Heart Percentage of Carcass Weight (*HPC*): Table 4 shows that only strain had a significant ($p \leqslant 0.05$) effect on HPC. *Arbor Acres broilers had* significantly ($p \leqslant 0.05$) lower HPC than those of Ross and Isa which had statically similar values (Table 4).

Gizzard Percentage of Carcass Weight (*GPC*): Table 4 shows that only strain and ST * S had a significant ($p \leqslant 0.05$) effect on GPC. Isa broilers had significantly ($p \leqslant 0.05$) the higher than those of Arbor Acres and Ross which had statically similar values (Table 4). Fig. 11 shows that female and male broilers of Isa had significantly ($p \leqslant 0.05$) higher GPC than those of other strains. Male broilers of Arbor Acres had significantly ($p \leqslant 0.05$) higher GPC than those of Ross whereas their female broilers had statically similar values.

Abdominal Fat Percentage of Carcass Weight (*AFPC*): Table 4 indicates that only strain and sex had a significant ($p \leqslant 0.05$) effect on AFPC. Ross broilers had significantly ($p \leqslant 0.05$) lower AFPC than those of other strains whereas female broilers had significantly ($p \leqslant 0.05$) higher AFPC than their male counterparts (Table 4).

5. Discussion

The results indicate a significant ($p \leqslant 0.05$) strain effect on broiler plant weight and other studied traits and their percentages of

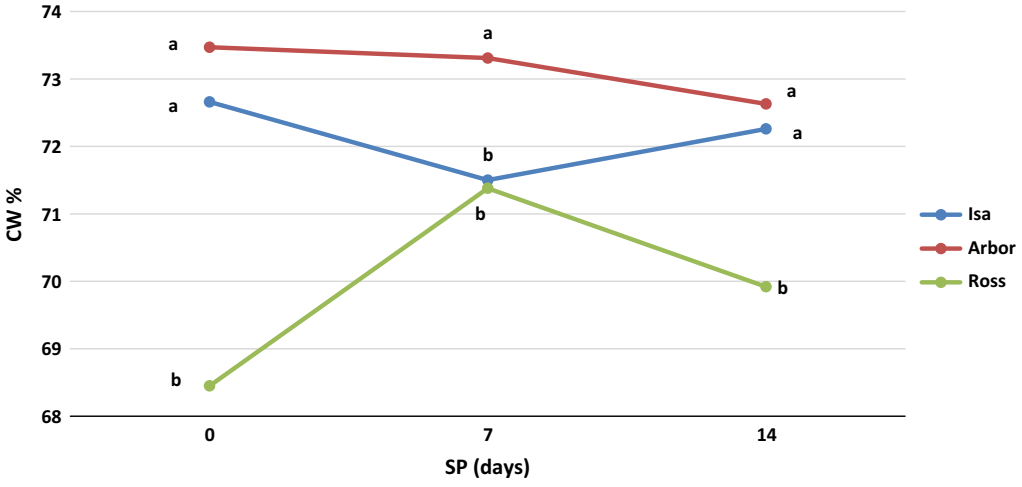

Figure 9 Effect of interaction between strain and eggs storage period (ST * SP) on percentage Carcass Weight (CW %).

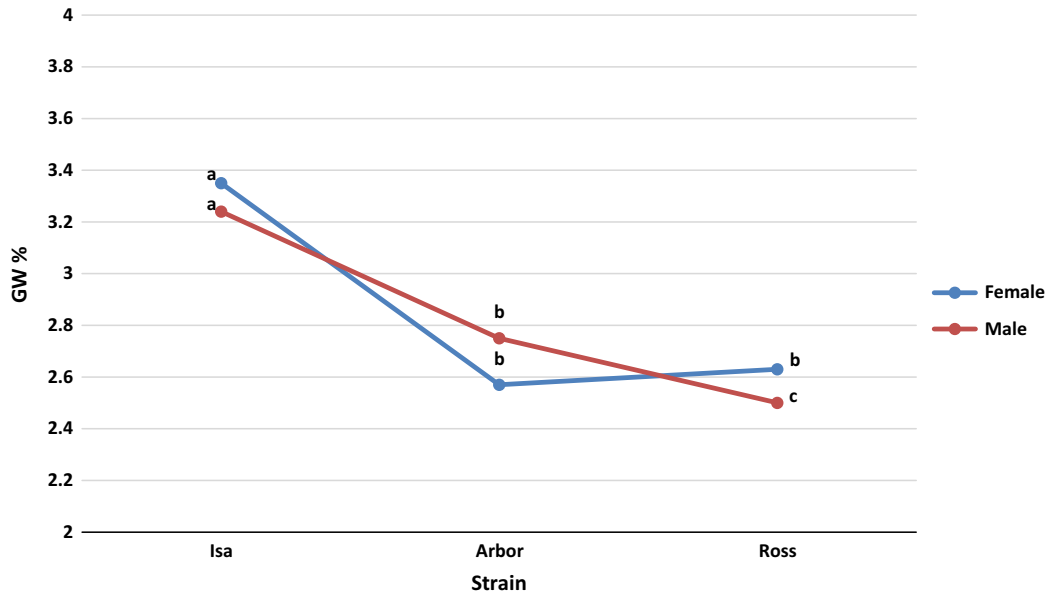

Figure 10 Effect of interaction between strain and sex (ST * S) on Gizzard Weight (GW) as a Percentage of Plant Body Weight (PBW).

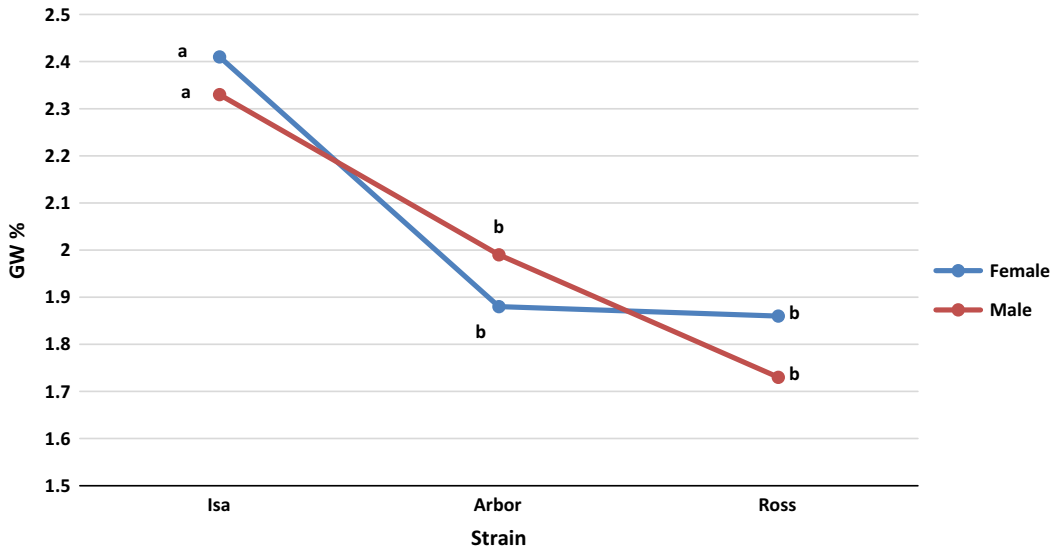

Figure 11 Effect of interaction between strain and sex (ST * S) on Gizzard Percentage of Carcass Weight (GPC).

plant and carcass weight whereas storage period and sex had a significant ($p \leqslant 0.05$) effect on weight of most studied traits. Broiler of Arbor Acres and of fresh hatching eggs and males had significantly ($p \leqslant 0.05$) the highest where Isa broilers and stored hatching eggs the lowest absolute value for most studied traits. On the other hand Ross broilers showed significantly ($p \leqslant 0.05$) the lowest plant and carcass percentage value of most studied traits compared to those of other broiler strains. Several investigators reported significant strain differences for broiler plant (Merkley et al., 1980; Kokoszynski et al., 2013), carcass (Hulet and Lorenz, 2001; Ojedapo et al., 2008; Olawumi and Fagbuaro, 2011; Shim et al., 2012; Kokoszynski et al., 2013; Malik et al., 2013), liver (Merkley et al., 1980; Malik et al., 2013), heart (Merkley et al., 1980; Olawumi and Fagbuaro, 2011), gizzard (Ojedapo et al., 2008; Malik et al., 2013) and abdominal fat weights (Merkley et al., 1980; Farran et al., 2000; Hulet and Lorenz, 2001; Kokoszynski et al., 2013; Malik et al., 2013). Broiler strain differences in plant weight and carcass traits might be mainly attributed to the different genetic makeup of broiler breeder strains. Significant strain differences for carcass and abdominal fat as a percentage of plant weight were also reported by several investigators (Kosarachukwu et al., 2010; Olawumi and Fagbuaro, 2011; Fernandes et al., 2013; Kokoszynski et al., 2013). Storage period of hatching eggs and sex had a significant ($p \leqslant 0.05$) effect on liver and abdominal fat weight percentage of plant and carcass weight, respectively whereas sex had a significant ($p \leqslant 0.05$) effect on carcass and liver weight as a percentage of plant weight. Broilers of fresh eggs showed significantly ($p \leqslant 0.05$) lower liver percentage value compared

Table 4 Effect of Strain (ST), Storage Period (SP) and Sex (S) on Liver (LPC), Heart (HPC), Gizzard (GPC) and Abdominal Fat (AFPC) Weights as a Percentage of Carcass Weight (CW).

Parameters	CW (gm)	LPC (%)	HPC (%)	GPC (%)	AFPC (%)
ST	**	NS	**	**	**
Isa	946.11[c]	2.79	0.90 ± 0.020[a]	3.30[a]	2.11[a]
Arbor	1342.22[a]	2.93	0.81 ± 0.020[b]	2.65[b]	2.17[a]
Ross	1191.73[b]	2.77	0.95 ± 0.020[a]	2.57[b]	1.61[b]
SP (days)	**	**	NS	NS	NS
0	1220.65[a]	2.70[b]	0.86 ± 0.020	2.77	2.09
7	1151.85[b]	2.84[ab]	0.88 ± 0.020	2.87	1.89
14	1107.56[b]	2.95[a]	0.92 ± 0.020	2.87	1.92
S	**	NS	NS	NS	**
F	1087.20[b]	2.87	0.89 ± 0.016	2.85	2.15[a]
M	1232.83[a]	2.79	0.89 ± 0.016	2.83	1.77[b]
Interactions					
ST * SP	NS	NS	NS	NS	NS
ST * S	*	NS	NS	*	NS
SP * S	NS	NS	NS	NS	NS
ST * SP * S	NS	NS	NS	NS	NS
MSE	±6.955	±0.026	±0.170	±0.393	±0.563

NS – Non-significant.
Means in the same column with different superscripts differ significantly ($p \leqslant .05$).
* Significant ($p \leqslant .05$).
** Highly significant ($p \leqslant .01$).

to those of stored hatching eggs whereas females showed higher carcass and liver percentage of plant weight and abdominal weight percentage of plant and carcass weight. Opposite to our results Ojedapo et al. (2008) and Alsobayel and Al-Miman (2010) reported higher gizzard weight for female than males at market age but Alsobayel and Al-Miman (2010) reported similar gizzard weight of broilers regardless of storage length of hatching eggs. Similar to our results, Alsobayel and Al-Miman (2010) reported higher carcass and abdominal fat weight for broilers of not stored hatching eggs. Strain storage period interaction (ST * SP) effect was significant ($p \leqslant 0.05$) for plant and liver weight and for carcass percentage of plant weight whereas strain sex interaction (ST * S) was significant ($p \leqslant 0.05$) for weight of most studied traits and gizzard percentage of plant and carcass weight. SP * S and ST * SP * S interactions were not significant for any of the studied traits. Male and female Broiler of Arbor Acres had significantly ($p \leqslant 0.05$) the highest and those of Isa the lowest plant and carcass weights. Arbor Acres broilers of hatching eggs stored for 7 and 14 days had the highest whereas those of Isa had the lowest plant and liver weight regardless of storage period of hatching eggs. Ross broilers showed the lowest carcass percentage of plant weight regardless of storage period of hatching eggs whereas Isa broilers showed the highest gizzard weight as a percentage of plant and carcass weight regardless of sex and Ross male broilers had the lowest gizzard percentage of carcass weight. Opposite to our results Alsobayel and Al-Miman (2010) reported no significant storage period sex interaction on carcass traits. It appears that very sparse information is available with regard to interaction between strain, storage period of hatching eggs and sex; therefore, more investigations are needed in this area. From the results of the study reported herein we conclude that strain of broiler breeder and storage period of hatching eggs had a pronounced effect upon most studied carcass traits. The results also showed that broilers of Arbor Acres and those of hatching eggs stored for seven days or less had in general the best carcass traits.

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